

From the RECEIVING OFFICE

To:  
 Wilson Gunn M'Caw & Co  
 41-51 Royal Exchange  
 Cross Street  
 Manchester  
 M2 7BD

PCT

NOTIFICATION OF THE INTERNATIONAL  
 APPLICATION NUMBER AND OF THE  
 INTERNATIONAL FILING DATE

(PCT Rule 20.5(c))

Date of mailing  
 (day/month/year)

13 MAR 2000

Applicant's or agent's file reference  
 P/14399.WO

## IMPORTANT NOTIFICATION

International application No.  
 PCT/GB00/00814

International filing date (day/month/year)  
 06/03/2000

Priority date (day/month/year)  
 06/03/1999

Applicant

Bolton Institute Of Higher Education et al

Title of the invention  
 Auxetic Materials

1. The applicant is hereby notified that the international application has been accorded the international application number and the international filing date indicated above.

2. The applicant is further notified that the record copy of the international application:



was transmitted to the International Bureau on

13 MAR 2000



has not yet been transmitted to the International Bureau for the reason indicated below and a copy of this notification has been sent to the International Bureau\*:



because the necessary national security clearance has not yet been obtained.



because (reason to be specified):

- \* The International Bureau monitors the transmittal of the record copy by the receiving Office and will notify the applicant (with Form PCT/IB/301) of its receipt. Should the record copy not have been received by the expiration of 14 months from the priority date, the International Bureau will notify the applicant (Rule 22.1(c)).

Name and mailing address of the receiving Office

The Patent Office  
 Cardiff Road, Newport  
 South Wales NP9 1RH

Facsimile No.

Authorized officer

Tracey Carter

Telephone No. 01633 814383

PCT

## REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For rec Office use only

International Application No.

International Filing Date

09/936069

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference  
(if desired) (12 characters maximum)

P/14399.WO

## Box No. I TITLE OF INVENTION

AUXETIC MATERIALS

## Box No. II APPLICANT

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

**BOLTON INSTITUTE OF HIGHER EDUCATION  
HIGHER EDUCATION CORPORATION  
DEANE ROAD,  
BOLTON,  
BL3 5AB.  
UNITED KINGDOM.**

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State (that is, country) of nationality:

UNITED KINGDOM

State (that is, country) of residence:

UNITED KINGDOM

This person is applicant  
for the purposes of:☐ all designated  
States☒ all designated States except  
the United States of America☐ the United States  
of America only☐ the States indicated in  
the Supplemental Box

## Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

**ALDERSON, KIM LESLEY  
21 KENT ROAD,  
FORMBY,  
LIVERPOOL,  
L37 6BG. UNITED KINGDOM.**

This person is:

☐ applicant only☒ applicant and inventor☐ inventor only (If this check-box  
is marked, do not fill in below.)

State (that is, country) of nationality:

UNITED KINGDOM

State (that is, country) of residence:

UNITED KINGDOM

This person is applicant  
for the purposes of:☐ all designated  
States☐ all designated States except  
the United States of America☒ the United States  
of America only☐ the States indicated in  
the Supplemental Box☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

## Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:

☒ agent☐ common representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

**QUEST, BARRY  
Wilson Gunn M'Caw  
41-51 Royal Exchange  
Cross Street  
Manchester M2 7BD.  
United Kingdom**

Telephone No.

0161 827-9400

Facsimile No.

0161 832 4905

Teleprinter No.

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III OTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
<i>If none of the following sub-boxes is used, this sheet should not be included in the request.</i>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p> <p><b>SIMKINS, VIRGINIA RUTH, TONACLIFFE HOUSE, TONACLIFFE ROAD, WHITWORTH, NR. ROCHDALE, LANCASHIRE. OL12 8SS. UNITED KINGDOM</b></p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input checked="" type="checkbox"/> applicant and inventor.</p> <p><input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality: <b>UNITED KINGDOM</b>	State (that is, country) of residence: <b>UNITED KINGDOM</b>
<p>This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality:	State (that is, country) of residence:
<p>This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality:	State (that is, country) of residence:
<p>This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality:	State (that is, country) of residence:
<p>This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p><input type="checkbox"/> Further applicants and/or (further) inventors are indicated on another continuation sheet.</p>	

Sheet No. ....

**Box No. V DESIGNATION STATES**

The following designations are hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):

**Regional Patent**

- ☒ **AP** ARIPO Patent: GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA** Eurasian Patent: AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP** European Patent: AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA** OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

**National Patent (if other kind of protection or treatment desired, specify on dotted line):**

- |   |  |
|---|--|
| <input checked="" type="checkbox"/> <b>AE</b> United Arab Emirates                  | <input checked="" type="checkbox"/> <b>LR</b> Liberia  |
| <input checked="" type="checkbox"/> <b>AL</b> Albania                               | <input checked="" type="checkbox"/> <b>LS</b> Lesotho  |
| <input checked="" type="checkbox"/> <b>AM</b> Armenia                               | <input checked="" type="checkbox"/> <b>LT</b> Lithuania  |
| <input checked="" type="checkbox"/> <b>AT</b> Austria                               | <input checked="" type="checkbox"/> <b>LU</b> Luxembourg   |
| <input checked="" type="checkbox"/> <b>AU</b> Australia                             | <input checked="" type="checkbox"/> <b>LV</b> Latvia   |
| <input checked="" type="checkbox"/> <b>AZ</b> Azerbaijan                            | <input checked="" type="checkbox"/> <b>MA</b> Morocco  |
| <input checked="" type="checkbox"/> <b>BA</b> Bosnia and Herzegovina                | <input checked="" type="checkbox"/> <b>MD</b> Republic of Moldova  |
| <input checked="" type="checkbox"/> <b>BB</b> Barbados                              | <input checked="" type="checkbox"/> <b>MG</b> Madagascar   |
| <input checked="" type="checkbox"/> <b>BG</b> Bulgaria                              | <input checked="" type="checkbox"/> <b>MK</b> The former Yugoslav Republic of Macedonia                      |
| <input checked="" type="checkbox"/> <b>BR</b> Brazil                                |  |
| <input checked="" type="checkbox"/> <b>BY</b> Belarus                               | <input checked="" type="checkbox"/> <b>MN</b> Mongolia   |
| <input checked="" type="checkbox"/> <b>CA</b> Canada                                | <input checked="" type="checkbox"/> <b>MW</b> Malawi   |
| <input checked="" type="checkbox"/> <b>CH and LI</b> Switzerland and Liechtenstein  | <input checked="" type="checkbox"/> <b>MX</b> Mexico   |
| <input checked="" type="checkbox"/> <b>CN</b> China                                 | <input checked="" type="checkbox"/> <b>NO</b> Norway   |
| <input checked="" type="checkbox"/> <b>CR</b> Costa Rica                            | <input checked="" type="checkbox"/> <b>NZ</b> New Zealand  |
| <input checked="" type="checkbox"/> <b>CU</b> Cuba                                  | <input checked="" type="checkbox"/> <b>PL</b> Poland   |
| <input checked="" type="checkbox"/> <b>CZ</b> Czech Republic                        | <input checked="" type="checkbox"/> <b>PT</b> Portugal   |
| <input checked="" type="checkbox"/> <b>DE</b> Germany                               | <input checked="" type="checkbox"/> <b>RO</b> Romania  |
| <input checked="" type="checkbox"/> <b>DK</b> Denmark                               | <input checked="" type="checkbox"/> <b>RU</b> Russian Federation   |
| <input checked="" type="checkbox"/> <b>DM</b> Dominica                              | <input checked="" type="checkbox"/> <b>SD</b> Sudan  |
| <input checked="" type="checkbox"/> <b>EE</b> Estonia                               | <input checked="" type="checkbox"/> <b>SE</b> Sweden   |
| <input checked="" type="checkbox"/> <b>ES</b> Spain                                 | <input checked="" type="checkbox"/> <b>SG</b> Singapore  |
| <input checked="" type="checkbox"/> <b>FI</b> Finland                               | <input checked="" type="checkbox"/> <b>SI</b> Slovenia   |
| <input checked="" type="checkbox"/> <b>GB</b> United Kingdom                        | <input checked="" type="checkbox"/> <b>SK</b> Slovakia   |
| <input checked="" type="checkbox"/> <b>GD</b> Grenada                               | <input checked="" type="checkbox"/> <b>SL</b> Sierra Leone   |
| <input checked="" type="checkbox"/> <b>GE</b> Georgia                               | <input checked="" type="checkbox"/> <b>TJ</b> Tajikistan   |
| <input checked="" type="checkbox"/> <b>GH</b> Ghana                                 | <input checked="" type="checkbox"/> <b>TM</b> Turkmenistan   |
| <input checked="" type="checkbox"/> <b>GM</b> Gambia                                | <input checked="" type="checkbox"/> <b>TR</b> Turkey   |
| <input checked="" type="checkbox"/> <b>HR</b> Croatia                               | <input checked="" type="checkbox"/> <b>TT</b> Trinidad and Tobago  |
| <input checked="" type="checkbox"/> <b>HU</b> Hungary                               | <input checked="" type="checkbox"/> <b>TZ</b> United Republic of Tanzania                                    |
| <input checked="" type="checkbox"/> <b>ID</b> Indonesia                             | <input checked="" type="checkbox"/> <b>UA</b> Ukraine  |
| <input checked="" type="checkbox"/> <b>IL</b> Israel                                | <input checked="" type="checkbox"/> <b>UG</b> Uganda   |
| <input checked="" type="checkbox"/> <b>IN</b> India                                 | <input checked="" type="checkbox"/> <b>US</b> United States of America                                       |
| <input checked="" type="checkbox"/> <b>IS</b> Iceland                               |  |
| <input checked="" type="checkbox"/> <b>JP</b> Japan                                 | <input checked="" type="checkbox"/> <b>UZ</b> Uzbekistan   |
| <input checked="" type="checkbox"/> <b>KE</b> Kenya                                 | <input checked="" type="checkbox"/> <b>VN</b> Viet Nam   |
| <input checked="" type="checkbox"/> <b>KG</b> Kyrgyzstan                            | <input checked="" type="checkbox"/> <b>YU</b> Yugoslavia   |
| <input checked="" type="checkbox"/> <b>KP</b> Democratic People's Republic of Korea | <input checked="" type="checkbox"/> <b>ZA</b> South Africa   |
|   | <input checked="" type="checkbox"/> <b>ZW</b> Zimbabwe   |
| <input checked="" type="checkbox"/> <b>KR</b> Republic of Korea                     | Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet: |
| <input checked="" type="checkbox"/> <b>KZ</b> Kazakhstan                            | <input checked="" type="checkbox"/> <b>TZ</b> Tanzania   |
| <input checked="" type="checkbox"/> <b>LC</b> Saint Lucia                           | <input checked="" type="checkbox"/> <b>AG</b> Antigua and Barbuda  |
| <input checked="" type="checkbox"/> <b>LK</b> Sri Lanka                             | <input checked="" type="checkbox"/> <b>DZ</b> Algeria  |

**Precautionary Designation Statement:** In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)

**Supplemental Box** If the Supplemental Box is not used, this sheet should not be included in the request.

1. If, in any of the Boxes, the space is insufficient to furnish all the information: in such case, write "Continuation of Box No. ..." [indicate the number of the Box] and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:
  - (i) if more than two persons are involved as applicants and/or inventors and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below;
  - (ii) if, in Box No. II or in any of the sub-boxes of Box No. III, the indication "the States indicated in the Supplemental Box" is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;
  - (iii) if, in Box No. II or in any of the sub-boxes of Box No. III, the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;
  - (iv) if, in addition to the agent(s) indicated in Box No. IV, there are further agents: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. II;
  - (v) if, in Box No. V, the name of any State (or OAPI) is accompanied by the indication "patent of addition," or "certificate of addition," or if, in Box No. V, the name of the United States of America is accompanied by an indication "continuation" or "continuation-in-part": in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI), the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;
  - (vi) if, in Box No. VI, there are more than three earlier applications whose priority is claimed: in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI;
  - (vii) if, in Box No. VI, the earlier application is an ARIPO application: in such case, write "Continuation of Box No. VI", specify the number of the item corresponding to that earlier application and indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed.
2. If, with regard to the precautionary designation statement contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded.
3. If the applicant claims, in respect of any designated Office, the benefits of provisions of the national law concerning non-prejudicial disclosures or exceptions to lack of novelty: in such case, write "Statement concerning non-prejudicial disclosures or exceptions to lack of novelty" and furnish that statement below.

#### Continuation of Box IV

DOWNEY, WILLIAM GERRARD  
GOODWIN, MARK  
HILL, RICHARD  
PHILLIPS, PATRICIA MARIE  
MIDDLEMIST, IAN ALASTAIR

of

WILSON GUNN M'CAW  
41-51 ROYAL EXCHANGE  
CROSS STREET  
MANCHESTER  
M2 7BD  
UNITED KINGDOM

Sheet No. ....

<b>Box No. VI - PRIORITY CLAIM</b>		<input type="checkbox"/> Further priority claim indicated in the Supplemental Box.		
Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country	regional application: regional Office	international application: receiving Office
item (1) 06/03/99 6 March 1999	9905145.0	GB		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): (1)

\* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(iv)). See Supplemental Box.

**Box No. VII INTERNATIONAL SEARCHING AUTHORITY**

**Choice of International Searching Authority (ISA)**  
(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):

ISA /

**Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):**

Date (day/month/year)

Number

Country (or regional Office)

**Box No. VIII CHECK LIST: LANGUAGE OF FILING**

This international application contains the following number of sheets:

request : 5  
description (excluding sequence listing part) : 18  
claims : 4  
abstract : 1  
drawings : 1  
sequence listing part of description : 1

Total number of sheets : 29

This international application is accompanied by the item(s) marked below:

1. ☐ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☐ other (specify): Forms 23/77

Figure of the drawings which should accompany the abstract:

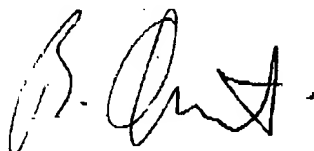
1

Language of filing of the international application:

English

**Box No. IX SIGNATURE OF APPLICANT OR AGENT**

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).



QUEST, BARRY

For receiving Office use only

1. Date of actual receipt of the purported international application:	2. Drawings:  <input type="checkbox"/> received:  <input type="checkbox"/> not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA /	
6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid.	

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

## PCT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner  
 US Department of Commerce  
 United States Patent and Trademark  
 Office, PCT  
 2011 South Clark Place Room  
 CP2/5C24  
 Arlington, VA 22202  
 ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

<b>Date of mailing</b> (day/month/year) 01 November 2000 (01.11.00)	<b>Applicant's or agent's file reference</b> P/14399.WO
<b>International application No.</b> PCT/GB00/00814	<b>Priority date</b> (day/month/year) 06 March 1999 (06.03.99)
<b>International filing date</b> (day/month/year) 06 March 2000 (06.03.00)	
<b>Applicant</b> ALDERSON, Kim, Lesley et al	

1. The designated Office is hereby notified of its election made:



in the demand filed with the International Preliminary Examining Authority on:

04 October 2000 (04.10.00)



in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

was not

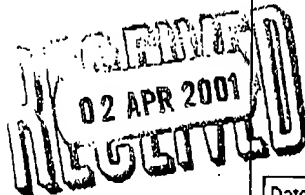
made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

<b>The International Bureau of WIPO</b> 34, chemin des Colombettes 1211 Geneva 20, Switzerland  Facsimile No.: (41-22) 740.14.35	<b>Authorized officer</b>  Pascal Piriou  Telephone No.: (41-22) 338.83.38
--	--

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

QUEST, BARRY  
Wilson Gunn M'Caw  
41-51 Royal Exchange  
Cross Street  
Manchester M2 7BD  
GRANDE BRETAGNE



PCT

NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing  
(day/month/year) 30.03.2001

Applicant's or agent's file reference  
P/14399.WO

IMPORTANT NOTIFICATION

International application No.  
PCT/GB00/00814

International filing date (day/month/year)  
06/03/2000

Priority date (day/month/year)  
06/03/1999

Applicant  
BOLTON INSTITUTE OF HIGHER EDUCATION et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/

European Patent Office  
D-80298 Munich  
Tel. +49 89 2399 - 0 Tx: 523656 epmu d  
Fax: +49 89 2399 - 4465

Authorized officer

de Santiago Gomez, A

Tel. +49 89 2399-8224





## PATENT COOPERATION TREATY

PCT

NOTIFICATION CONCERNING  
SUBMISSION OR TRANSMITTAL  
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

From the INTERNATIONAL BUREAU

To:

QUEST, Barry  
Wilson Gunn M'Caw  
41-51 Royal Exchange  
Cross Street  
Manchester M2 7BD  
ROYAUME-UNI

Date of mailing (day/month/year) 18 April 2000 (18.04.00)	
Applicant's or agent's file reference P/14399.WO	<b>IMPORTANT NOTIFICATION</b>
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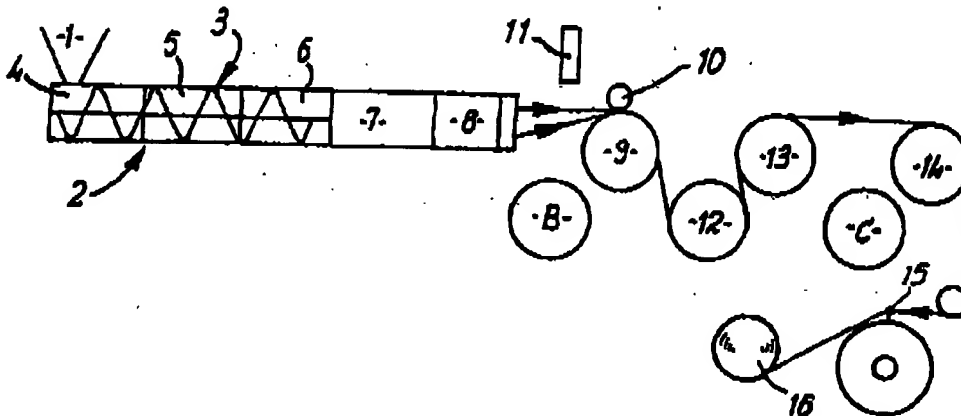
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## (57) Abstract

An auxetic material, which has a negative Poisson ratio so that it has the property of expanding or contracting transversely to a direction in which it is extended or compressed, is made in filamentary or fibrous form. A suitable process involves cohering and extruding heated polymer powder so that the cohesion and extrusion is effected with spinning to produce auxetic filaments. Typically the powder is heated to a temperature sufficient to allow some degree of surface melting yet not high enough to enable bulk melting.

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AUXETIC MATERIALS

This invention relates to synthetic auxetic materials, that is, to polymeric materials having a negative Poisson ratio whereby, when stretched in one direction by application of a tensile load, the material expands transversely to that direction. Alternatively, when compressed in one direction, the material contracts transversely to that direction.

Synthetic auxetic materials have been known since 1987. In the first instance, and as described in U.S. Patent 4668557, auxetic materials were prepared as open-celled polymeric foam, negative Poisson ratio properties being obtained as a consequence of mechanical deformation of the foam by compression.

More recently, auxetic materials have been formed as polymer gels, carbon fibre composite laminates, metallic foams, honeycombs and microporous polymers.

Published patent specification WO 91/01210 describes a polymeric material having an auxetic microstructure of fibrils interconnected at nodes. As described, this material is obtained by a process which comprises compacting polymer particles at elevated temperatures and pressures and then deforming the compacted polymer by draw-assisted extrusion through a die to produce a cylindrical rod of auxetic material.

A typical process may use a compaction stage with a specially designed processing rig heated to 110 - 125°C with a blank die inserted.

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Polymer powder is added into a barrel of the rig and is allowed to come to temperature for between 3 - 10 minutes before compaction pressure is applied with a ram at a rate of up to 140mm/min. The pressure is held at 0.04GPa for 10 - 20 minutes and the resulting rod of compacted material is then removed from the barrel of the processing rig and allowed to air cool. The processing rig is then fitted with an extrusion die in place of the blank die and heated up to 160°C. The compacted rod is reinserted into the barrel and sintered at 160°C for 20 minutes. It is then immediately extruded at a rate of 500mm/min at 160°C through a conical die of geometry entry diameter 15mm, exit diameter 7 - 7.5mm, cone semi-angle 30° and capillary length 3.4mm.

The material obtained from this typical process has auxetic properties derived from the microstructure of the material, namely fibrils interconnected at nodes capable of transverse expansion and increased porosity when the material is stretched.

Auxetic materials are of interest as a consequence of predicted enhancement of mechanical properties such as plane strain fracture toughness and shear modulus. This enhancement has been demonstrated in practice in tests in terms of indentation resistance and ultrasound attenuation with blocks of auxetic microporous ultra high molecular weight polyethylene.

Enhancements in hardness of up to three times at low loads, and very

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large enhancements (again up to three times) in the attenuation coefficient (i.e. how much of an ultrasound signal is absorbed) are exhibited as between the auxetic material and conventional polyethylene.

Known auxetic materials have been made in the form of bodies with  
6 relatively low aspect ratios, and in the case of auxetic microporous polymers these have been made from powder using a three stage process involving compaction, sintering and ram extrusion through a conical die as described above.

Hitherto therefore auxetic materials have not successfully been made  
10 in the form of fibres (i.e. with high aspect ratios), despite the interest in such materials. Typically a fibre is an elongate body having a length at least 100 times its diameter.

An object of the present invention is to provide a viable process for the production of auxetic materials in fibre form.

15 According to one aspect of the invention therefore there is provided an auxetic polymeric material which is of filamentary or fibrous form.

According to a further aspect of the invention therefore there is provided a method of forming an auxetic material comprising cohering and extruding heated thermoformable particulate polymeric material, wherein  
20 cohesion and extrusion is effected with spinning to produce filamentary material having auxetic properties.

With this arrangement, surprisingly the use of spinning with cohesion

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and extrusion provides an effective means of producing auxetic material in filamentary form. It has been found that this process can provide an auxetic microstructure of fibrils and nodes, as with the above mentioned prior art process, but without requiring the separate compaction and sintering stages of the prior art.

Most preferably the process of the invention is performed without, or substantially without, any separate compaction or sintering stages, compaction or rather cohesion and heating being effected solely as part of extrusion in the spinning process. Preferably also there is no (or substantially no) separate post-extrusion draw stage, finalisation of mechanical treatment being effected wholly or substantially wholly during extrusion rather than subsequently thereto.

The spinning process is preferably performed at a temperature which is high enough to give rise to cohesion of polymer particles sufficient to permit production of filaments, but without causing actual melting and complete coalescence of the particles into a liquid form. This temperature range is usually defined by reference to a typical DSC (Differential Scanning Calorimetry) diffusion endotherm and would fall on the low temperature side of that endotherm.

It is believed that for a fibre to be auxetic its maximum melting temperature and its DSC-derived % crystallinity should be as close as possible to those of the powder from which it has been derived. Thus, it

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is desirable that the auxetic fibres should comprise powder particles which have been sintered together at a temperature low enough to allow some degree of surface melting yet not high enough to enable bulk melting and hence reduction in crystallinity.

- 5        The particles are preferably small sized rough surfaced particles, particularly irregularly shaped and sized particles although varying within a defined size range, say up to 300 $\mu$ m diameter  $\pm$  10%.

          The process may be performed using standard melt extrusion apparatus having an extruder plate (spinneret) with say 40 holes each of  
10    0.55mm diameter.

          The apparatus may have three zones, a barrel zone, an adapter zone and a die zone which are capable of independent temperature control. The barrel zone may itself have three zones (a feed, compression and metering zone) which may be capable of independent temperature control. However,  
15    a common temperature may be employed throughout.

          Preferably screw extrusion rather than ram extrusion is used, operating at say 10 rpm.

          Appropriate devices may be used for collecting and cooling produced filaments, preferably without applying any appreciable drawing traction  
20    thereto. Cooling may be achieved by air cooling, and/or passing the filaments around a cooling roller, or otherwise. Extruded hot filaments may run between a cooling roller and a nip roller, and an air knife may be



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provided at an appropriate height say 5mm above the filaments. Further rollers may be provided for guiding the cooled filaments e.g. to a vertical drop and collection point. The rollers may be driven at a relatively low speed, say around 5 metres per minute, to avoid application of significant traction force.

The process may be applied to polypropylene in which case the temperature used may be say 159°C. Other polymeric materials, such as nylon or other polyolefin or polyamide materials may be used particularly polyethylene such as ultra high molecular weight polyethylene. The polymeric material may be mixed with or incorporate any other suitable materials such as fillers, other polymers, etc.

The process may be applied to the production of continuous monofilaments, or short filaments or fibres, and these may be twisted or otherwise combined to give multi-filament or fibrous yarns.

These filamentary or fibrous materials may be formed into textile structures such as woven, knitted or felted fabrics alone or in combination with any other suitable materials.

Filaments or fibres made in accordance with the invention may be used as reinforcements in composite materials to impart enhanced energy absorption properties and fibre pullout resistance.

Textile structures incorporating or made from filaments or fibres made in accordance with the invention may be used in protective clothing where

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enhanced indentation properties and low velocity impact resistance are advantageous. Such textile structures may also be used in healthcare. There are also other applications where the material of the invention can be used advantageously.

5           The invention therefore also provides an auxetic material of filamentary or fibrous form, preferably formed by the process described above, and textile structures made with such auxetic material.

The invention will now be described further by way of example only and with reference to the accompanying drawings in which:

10   Figure 1     is a diagrammatic representation of one form of apparatus used in performing the process of the invention; and  
Figure 2     is a diagrammatic representation of the structure of a fibre formed by the process of the invention.

Figure 1 shows conventional melt extrusion apparatus used in  
15 performing the process of the invention, by way of example.

The apparatus has a powder hopper 1 leading to a barrel 2 containing an Archimedean feed screw 3. The extruder barrel 2 has three zones feed, compression and metering zones 4, 5, 6. The screw 3 has a 3:1 compression ratio, a 1 inch (2.54cm) diameter and a length-to-diameter ratio  
20 of 24:1.

The barrel 2 is connected via a diameter-reducing adapter section 7 to a die 8 comprising a 40-hole spinneret, the holes being of 0.55mm

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diameter.

In front of the die there is a cooling roller 9 with a pinch roller 10 and an air knife 11, and subsequent guide rollers 12-14, a guide rail 15 and a wind-up roller 16.

5 A heater is provided (not shown) for heating the barrel 2 at the three separate zones 4, 5, 6 along its length, and also at adapter 7 and die 8.

The heating arrangement permits different temperatures to be maintained for each of these and conventionally this would be in an increasing manner from zone one 4 to zone three 6.

10 In use, for polypropylene powder, zone temperature differences might typically be from 10 - 20°C. In accordance with an example of the present invention a temperature of 159°C is maintained throughout the three zones 4-6 of the barrel 2, adapter 7, and die 8, and polypropylene powder is fed from the hopper 1 to the barrel 2.

15 The polypropylene powder in this example has a particle diameter  $< 300\mu\text{m}$ , the diameters of individual particles varying within a range of  $\pm 10\%$  of a medium diameter. All particles have irregular shapes and rough surfaces.

20 The polymer used is Coathylene PB 0580, as produced by Plast-Labor S.A., CH-1630 Bulle, Switzerland.

The screw 3 is driven at a controlled relatively slow rate of 10rpm (corresponding to a throughput of 3.6 gms per minute) and this causes the

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powder to be advanced along the zones 4-6 of the barrel 2 to the adapter 7 and the die 8. This speed, is selected in relation to other parameters, namely the powder morphology, the temperature, the length of the barrel 2 and adapter 7, and the cross-sectional characteristics of the barrel 2, adapter 7 and holes of the die 8. The powder particles are thereby caused to cohere together and flow through the die holes.

The screw speed is selected to be as slow as possible, and the temperature is as low as possible, whilst achieving smooth fibre characteristics.

The temperature is below the melting point of the polymer so that the particles cohere to form a continuous, fluent body without losing their integrity. Thus, although the apparatus is derived from conventional melt extrusion apparatus, the process involves 'melt' or flow spinning, but without melt extrusion occurring.

In particular, and as discussed further below, the powder particles are sintered together at a temperature low enough to allow some degree of surface melting but not high enough to give bulk melting.

The material flows through the die 8 and is taken up by the pinch rollers 9, 10 without application of any appreciable traction. The material is therefore spun or extruded but not significantly drawn.

The 'molten' filaments leaving the die 8 are picked up with a metal rod and draped around the cooling roller 9 prior to engagement of the pinch

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roller 10. The pinch roller 10 is then engaged and the air knife moved in position at a setting of 5mm above the path of the filaments.

From the pinch rollers 9, 10, the filaments are taken down from the cooling roller 10 and are passed under roller 12, up and over roller 13 and  
5 then straight across to roller 14. The filaments are then fed vertically downwards and slid over the guide rail 15 to the wind-up roller 16.

In this example the rollers 9, 10, 12-14, 16 are driven to run at a slow speed of 2 metres per minute to achieve guide of the filaments without applying any appreciable drawing or traction forces. However, at higher  
10 barrel extrusion speeds, proportionally higher roller speeds would enable the same fibre characteristics to be achieved. Other rollers such as would be used with apparatus of this kind where drawing is required are not used here.

As a consequence of the above described procedure the filamentary  
15 material produced from the die 5 has a micro-structure of fibrils 17 linked by nodes 18, as shown in Figure 2, which gives rise to auxetic properties.

This microstructure is known to provide auxetic properties but has hitherto been obtained by compaction and sintering of the polymer powder, which may be followed by draw extrusion of a relatively large diameter  
20 cylindrical rod (say up to 10 or 15mm). It has been found, surprisingly, that the auxetic microstructure can be obtained with the above described 'melt' spinning process without use of separate compacting and sintering stages

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or paying careful attention to die geometry.

The following table, Table 1, gives detailed parameters for the above described example of the invention, in the column identified Batch M. These parameters are compared with parameters of two other batches, Batch B and Batch H using the same polypropylene powder. Also, characteristic parameters of a sample of raw powder are shown.

Extrusion process parameters	Characteristic parameters (DSC)	Batch B	Batch H	Batch M	PP Powder
Temp Screw Feed Zone (4) - (°C)		173	163	155	
Temp Screw Compression Zone (5) - (°C)		185	166	159	
Temp Screw Metering Zone (6) - (°C)		205	168	159	
Temp Adaptor Zone (7) - (°C)		212	165	158	
Temp Die Zone (8) - (°C)		210	168	158	
RPM		25	30	10	
MPM		5	6	2	
	T <sub>onset</sub> - (°C)	151	155	156	149
	T <sub>max</sub> - (°C)	165	166	165	165
	% crystallinity	32.3	24.8	45.5	47.8

As can be seen from the table, the batch of raw powder examined starts to melt at 149°C and melts completely at 165°C, and the % crystallinity of the powder is 47.8%. Parameters were derived using

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Differential Scanning Calorimetry conducted on a Polymer Labs PL DSC under flowing nitrogen at a heating rate of 10°C/min from 30-200°C. Batch M has somewhat similar characteristic parameters to the raw powder, particularly the crystallinity percentage.

5           Micrographic analysis of Batch M fibres showed that they had auxetic properties. That is, the fibres showed a structure of fibrils attached to modules. Also, extension of the fibres caused these to expand laterally.

          Batch B and Batch H were processed at higher temperatures and higher throughputs. As shown in the table this resulted in a much reduced  
10           crystallinity percentage. Micrographic analysis did not reveal any significant auxetic properties.

          This demonstrates that, to attain auxetic properties, it is desirable for the powder particles to be sintered together at a temperature low enough to allow some degree of surface melting yet not high enough to enable bulk  
15           melting whereby the fibres remain as close as possible to the raw powder particularly with regard to the DSC-derived % crystallinity.

          The resulting filamentary auxetic material can be used as reinforcing fibres, or in textile structures, and has advantageous properties suited to a range of applications.

20           Some possible applications can be identified as follows.

          Auxetic fibres can be used as fibre reinforcements in composite materials e.g. polyolefin auxetic fibres in a polyolefin matrix. The auxetic

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fibres improve resistance to fibre pull out and fibre fracture toughness, and give enhanced energy absorption properties. Sonic, ultrasonic and impact energy can be absorbed enabling superior composites to be made for sound insulation of walls of buildings, body parts for submarines or other vehicles, etc, bumpers for cars, etc. Auxetic materials also respond to impact to give local densification thereby giving enhanced indentation resilience.

Auxetic fibres can be used alone or in combination with other materials for personal protective clothing or equipment as a consequence of the superior energy absorption and impact resistance properties. Crash helmets and body armour (e.g. bullet proof vests) are examples of applications.

For such an application it may be desirable to make the protective material in the form of an auxetic macrostructure made from auxetic fibres (i.e. a hierarchical auxetic material). This would enable a single-component protective material to perform the combined energy absorption and indentation resistance roles, rather than having separate layers to perform each of these tasks in a dual-component material.

These properties should also lead to enhanced sports protective clothing, e.g. shin pads, knee pads, batting gloves etc. The possibility exists of producing protective clothing made from auxetic fibres which have equivalent protective performance to those made from non-auxetic fibres but which are lighter and/or thinner due to the benefits associated with the



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auxetic property.

Auxetic materials have pore size/shape and permeability variations leading to superior filtration/separation performance in several ways when compared to non-auxetic materials. Application of an applied tensile load on a non-auxetic porous material causes the pores to elongate in the direction of the applied load, which would tend to increase the filter porosity. However, the positive Poisson's ratio of non-auxetic materials causes the pores to contract in the transverse direction, thus reducing the overall porosity in competition with the increase in porosity due to longitudinal pore extension. For an auxetic porous material, on the other hand, the pores extend in both the loading and transverse directions, leading to enhanced porosity variations when compared with the non-auxetic equivalent. Benefits for auxetic filter materials, therefore, include release of entrapped particulates (leading to potential for cleanable filters and filters/membranes where a controlled release of a dose of particles/cells/molecules of a specific size/shape are required, e.g. drug-release materials) and self-regulating filters to compensate for pressure build-up due to filter fouling.

Non-auxetic microporous polypropylene fibres have been proposed for use in cloth filters. Also, non-auxetic microporous fibres, possibly hollow, are themselves used as separation materials in which a two-phase mixture (solid and liquid, for example) is passed down the middle of the fibre, with

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one phase then passing through the walls of the fibre whilst the other continues to pass down the middle. Hollow polypropylene fibres are employed in, for example, mechanical lung applications in which carbon dioxide is removed from the blood of the patient, and fresh oxygen is supplied to the patient. An auxetic equivalent should have superior performance in terms of selectivity and cleanability in these applications.

Polypropylene fibres are employed in rope or cord and fishnet applications due to their high strength and low weight (i.e. floatation) properties. In addition to the usual methods of strengthening ropes (due to twisting mechanisms between fibres etc) the auxetic effect can further enhance the strength properties of ropes and fishnets.

In the case of two adjacent non-auxetic fibres, application of tension of the fibres causes them to elongate in the direction of tension and to contract radially due to the positive Poisson's ratio. Hence (neglecting twist and friction effects etc.) extension of the fibres is simply governed by the fibre Young's modulus. For two adjacent auxetic fibres, however, the elongation in the direction of applied tension is accompanied by a concomitant increase in radial expansion due to the negative Poisson's ratio. For two fibres in contact this causes radial compression between the fibres which is, therefore, converted into a longitudinal contraction (due to the negative Poisson's ratio) in direct competition to the extension due to the applied tensile load. Hence, in this case the overall longitudinal extension

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of the fibres is lower than that which would be expected from the fibre Young's modulus as a direct consequence of the auxetic effect. In other words, to a first approximation the extension of two or more non-auxetic fibres in radial contact will be equal to that of a single fibre of equal  
5 Young's modulus in isolation and subject to the same applied stress, whereas the extension of two or more auxetic fibres in radial contact will be less than that of a single fibre of equal Young's modulus in isolation. Hence, a rope or fishnet made from auxetic fibres will have enhanced strength properties.

10 In addition to the strength enhancements, auxetic fibres also exhibit improved wear resistance due to having enhanced indentation properties. This leads to ropes and fishnets having enhanced abrasion properties to counteract the effects of ingress of, for example, sand grains during use. Improved wear resistance should also be useful in other fibre applications  
15 such as upholstery fabrics etc.

Naturally-occurring auxetic biomaterials are known, for example cow teat skin, cat skin and certain forms of bone. In developing synthetic replacement biomaterials it is desirable to consider auxetic functionality in order to ensure an adequate match in the mechanical properties of the real  
20 and synthetic materials. Currently, fibrous biomedical materials include cartilage, surgical implants and suture anchors or muscle/ligament anchors, where the additional benefit of a microporous structure should promote

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bone in-growth. The use of auxetic fibres leads to benefits by ensuring an adequate match in mechanical properties, improved strength and wear resistance for load bearing components (e.g. cartilage), and improved 'anchoring' properties.

5           Auxetic fibres can be used in bandages and pressure pads in woundcare. Important properties in these applications may include that the bandage maintains pressure on the wound to prevent swelling of the wound, and enables the wound to breathe through the macropores of the bandage structure whilst also preventing infection of the wound. Ideally the  
10       bandage may also enable wound-healing to occur by application of an appropriate wound-healing agent.

          A tubular bandage or pad or strip formed from auxetic fibres can be applied around a limb. Auxetic fibres would tend to act to maintain the breathability and pressure applied by an auxetic bandage on the wound  
15       despite any swelling of the wound.

          Furthermore, if the auxetic fibres are 'loaded' with a wound-healing component (i.e. the wound-healing component particles are initially entrapped within the auxetic fibre microstructure) then the extension in length and thickness of the fibres due to wound swelling would open up the  
20       fibre micropores, thus enabling release of the wound-healing component to counteract the initial swelling.

Other miscellaneous applications are:

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fire-retardant (FR) fibres – due to incorporating FR component in pores of fibre by extending fibre during processing and then entrapping FR component by closing up pores due to release of extension after processing;

5 drug-delivery fibrous materials – similar to FR fibres where drug molecules/particulates are entrapped within fibres and subsequently released by extending fibres to open up pores;

other fibres which need to contain an additional component within the pores (e.g. dye molecules for dyeability);

10 composite fibres – in which one or more components are auxetic fibres (e.g. winding a dyeable fibre around an auxetic fibre in order to produce a fibre having benefits due to auxetic effect and also dyeability property);

15 fibrous seals – to exploit advantages due to auxetic property in seal and gasket applications.

It is of course to be understood that the invention is not intended to be restricted to the details of the above embodiment which are described by way of example only.

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CLAIMS

1. An auxetic polymeric material which is of filamentary or fibrous form.
2. A method of forming an auxetic material comprising cohering and extruding heated thermoformable particulate polymeric material,  
5 wherein cohesion and extrusion is effected with spinning to produce  
6 filamentary material having auxetic properties.
3. A method according to claim 2 which is performed substantially without any compaction or sintering stages separate to the extrusion with spinning process.
- 10 4. A method according to claim 2 or 3 which is performed substantially without any separate post-extrusion draw stage.
5. A method according to any one of claims 1 to 4 which is performed at a temperature which is high enough to give rise to cohesion of polymer particles sufficient to permit production of filaments, but  
15 without causing actual melting and complete coalescence of the particles into a liquid form.
6. A method according to any one of claims 1 to 5 which is performed with rough surfaced particles of irregular shape and size.
7. A method according to claim 6 wherein the particles are up to 300 $\mu$ m  
20 diameter.
8. A method according to any one of claims 1 to 7 performed using melt extrusion apparatus having a barrel zone, an adapter zone and a die

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zone with an extruder plate, which zones are capable of independent temperature control.

- 5           9. A method according to claim 8 wherein the barrel zone itself has three zones, namely feed, compression and metering zones, which are capable of independent temperature control.
10. A method according to claim 8 or 9 wherein the barrel zone contains an extrusion screw.
- 10          11. A method according to any one of claims 8-10 wherein extruded filaments from the die are passed around rollers substantially without drawing traction.
12. An auxetic polymeric material of filamentary or fibrous form produced by the method of any one of claims 1 to 11.
13. An auxetic polymeric material according to claim 1 or 12 wherein the polymeric material comprises polypropylene.
- 15          14. A fabric formed from an auxetic polymeric material according to any one of claims 1, 12, 13.
15. A fibre-reinforced composite material containing reinforcing fibres which are auxetic polymeric materials according to any one of claims 1, 12, 13.
- 20          16. A composite material according to claim 15 used as sound insulation for building walls.
17. A composite material according to claim 15 used as a vehicle body

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PCT/GB00/00814

-21-

part.

18. A composite material according to claim 15 used as a car bumper.
19. Personal protective clothing or equipment made from material comprising an auxetic polymeric material according to any one of  
5 claims 1, 12, 13.
20. Personal protective clothing or equipment according to claim 19 in the form of a crash helmet.
21. Personal protective clothing or equipment according to claim 19 which is in the form of a projectile-resistant or bullet proof vest.
- 10 22. Personal protective clothing or equipment according to claim 19 which is in the form of a shin pad.
23. Personal protective clothing or equipment according to claim 19 which is in the form of a knee pad.
- 15 24. Personal protective clothing or equipment according to claim 19 which is in the form of a glove.
25. A filter made from material comprising an auxetic polymeric material according to any one of claims 1, 12, 13.
26. A rope or cord formed from twisted fibres, said fibres comprising an auxetic polymeric material according to any one of claims 1, 12, 13.
- 20 27. A fishnet made from ropes or cords according to claim 26.
28. A replacement biomaterial comprising an auxetic polymeric material according to any one of claims 1, 12, 13.



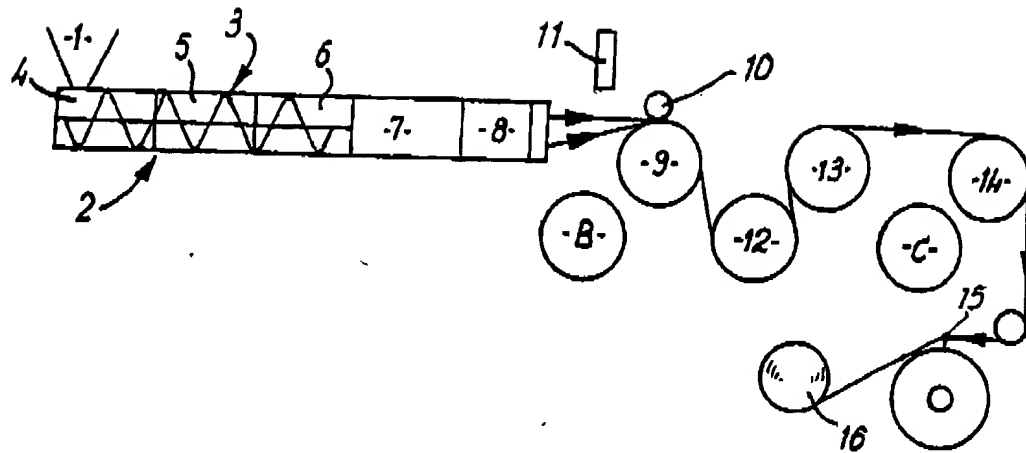
WO 00/53830

PCT/GB00/00814

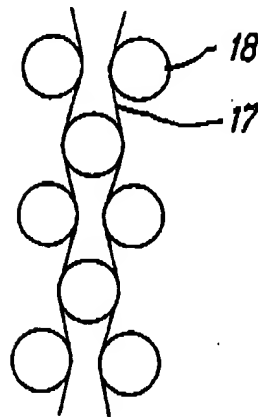
-22-

29. A bandage or wound pressure pad formed from a material comprising an auxetic polymeric material according to any one of claims 1, 12, 13.
30. A seal or gasket made from a material comprising an auxetic polymeric material according to any one of claims 1, 12, 13.
- 5 31. An auxetic polymeric material according to any one of claims 1, 12, 13 incorporating an entrapped, releasable substance in pores thereof.

1/1



**FIG. 1**



**FIG. 2**

## INTERNATIONAL SEARCH REPORT

Inter Application No

PCT/GB 00/00814

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC 7 D01D5/08 D01F6/06

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
 IPC 7 D01D D01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 187 390 A (GORE ROBERT W) 5 February 1980 (1980-02-05) claims 1,17,18	1,12, 14-31
X	NKANSAH M A ET AL: "Modelling the effects of negative Poisson's ratios in continuous-fibre composites" JOURNAL OF MATERIALS SCIENCE, vol. 28, 1993, pages 2687-2692, XP002142194 page 2687, column 2, line 1 - line 16 -/-	1,12, 14-31

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "B" document member of the same patent family

Date of the actual completion of the international search

10 July 2000

Date of mailing of the international search report

28/07/2000

Name and mailing address of the ISA

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 Fax: (+31-70) 340-3016

Authorized officer

Tarrida Torrell, J

## INTERNATIONAL SEARCH REPORT

Int. Application No

PCT/GB 00/00814

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CADDOCK B D ET AL: "Microporous materials with negative Poisson's ratios: I. Microstructure and mechanical properties" JOURNAL OF PHYSICS. D: APPLIED PHYSICS, vol. 22, 1989, pages 1877-1882, XP000915206 page 1877, column 1, line 1 - line 19	1,12, 14-31
X	PICKLES A P ET AL: "THE EFFECT OF POWDER MORPHOLOGY ON THE PROCESSING OF AUXETIC POLYPROPYLENE (PP OF NEGATIVE POISSON'S RATIO)" POLYMER ENGINEERING & SCIENCE, US, SOCIETY OF PLASTICS ENGINEERS, vol. 36, no. 5, 15 March 1996 (1996-03-15), pages 636-642, XP000594968 ISSN: 0032-3888 the whole document	1,6,7, 12-31
A	BURKE M: "A STRETCH OF THE IMAGINATION" NEW SCIENTIST, GB, IPC MAGAZINES, LONDON, vol. 154, no. 2085, 7 June 1997 (1997-06-07), pages 36-39-39, XP002107878 ISSN: 0262-4079 the whole document	1-31
A	EP 0 253 513 A (NIPPON OIL CO LTD) 20 January 1988 (1988-01-20) the whole document	2-5

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.

PCT/GB 00/00814

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US 4187390 A	05-02-1980	BE 767423 A	18-10-1971
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		DE 3781056 T	18-03-1993
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		JP 63159408 A	02-07-1988
		US 4879076 A	07-11-1989

## PATENT COOPERATION TREATY

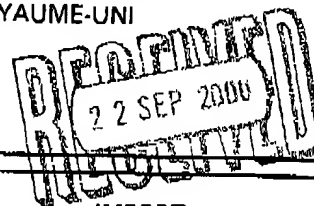
PCT

From the INTERNATIONAL BUREAU

NOTICE INFORMING THE APPLICANT OF THE  
COMMUNICATION OF THE INTERNATIONAL  
APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:

QUEST, Barry  
Wilson Gunn M'Caw  
41-51 Royal Exchange  
Cross Street  
Manchester M2 7BD  
ROYAUME-UNI

Date of mailing (day/month/year) 14 September 2000 (14.09.00)		
Applicant's or agent's file reference P/14399.WO		
International application No. PCT/GB00/00814	International filing date (day/month/year) 06 March 2000 (06.03.00)	Priority date (day/month/year) 06 March 1999 (06.03.99)
Applicant BOLTON INSTITUTE OF HIGHER EDUCATION et al		

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:  
**AU,KP,KR,US**

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:  
**AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CR,CU,CZ,DE,DK,DM,EA,EE,EP,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW**  
The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 48.1(a-bis)).
3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on 14 September 2000 (14.09.00) under No. WO 00/53830

**REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)**

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 18 months from the priority date.

It is the applicant's sole responsibility to monitor the 18-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

**REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))**

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer  J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

## Continuation of Form PCT/IB/308

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF  
THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

Date of mailing (day/month/year) 14 September 2000 (14.09.00)	IMPORTANT NOTICE
Applicant's or agent's file reference P/14399.WO	International application No. PCT/GB00/00814
<p>The applicant is hereby notified that, at the time of establishment of this Notice, the time limit under Rule 46.1 for making amendments under Article 19 has not yet expired and the International Bureau had received neither such amendments nor a declaration that the applicant does not wish to make amendments.</p>	

## PATENT COOPERATION TREATY

PCT

From the INTERNATIONAL BUREAU

INFORMATION CONCERNING ELECTED  
OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

To:

QUEST, Barry  
Wilson Gunn M'Caw  
41-51 Royal Exchange  
Cross Street  
Manchester M2 7BD  
ROYAUME-UNI

Date of mailing (day/month/year) 01 November 2000 (01.11.00)		IMPORTANT INFORMATION	
Applicant's or agent's file reference P/14399.WO			
International application No. PCT/GB00/00814	International filing date (day/month/year) 06 March 2000 (06.03.00)	Priority date (day/month/year) 06 March 1999 (06.03.99)	
Applicant BOLTON INSTITUTE OF HIGHER EDUCATION et al			

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

AP : GH,GM,KE,LS,MW,SD,SL,SZ,TZ,UG,ZW

EP : AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE

National : AU,BG,CA,CN,CZ,DE,IL,JP,KP,KR,MN,NO,NZ,PL,RO,RU,SE,SK,US

2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

EA : AM,AZ,BY,KG,KZ,MD,RU,TJ,TM

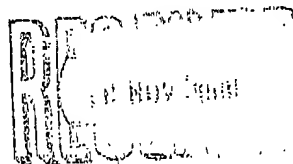
OA : BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG

National : AE,AL,AM,AT,AZ,BA,BB,BR,BY,CH,CR,CU,DK,DM,EE,ES,FI,GB,GD,GE,GH,  
GM,HR,HU,ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MW,MX,PT,SD,  
SG,SI,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW

3. The applicant is reminded that he must enter the "national phase" before the expiration of 30 months from the priority date before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing, if prescribed, a translation of the International application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

The entry into the European regional phase is postponed until 31 months from the priority date for all States designated for the purposes of obtaining a European patent.



The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland  Facsimile No. (41-22) 740.14.35	Authorized officer:  Pascal Pinou  Telephone No. (41-22) 338.83.38
--	--



# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>P/14399.WO</b>	<b>FOR FURTHER ACTION</b> <small>see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.</small>	
International application No. <b>PCT/GB 00/ 00814</b>	International filing date (day/month/year) <b>06/03/2000</b>	(Earliest) Priority Date (day/month/year) <b>06/03/1999</b>
Applicant  <b>BOLTON INSTITUTE OF HIGHER EDUCATION et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 03 sheets.  
☒ It is also accompanied by a copy of each prior art document cited in this report.

**1. Basis of the report**

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :
- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of Invention is lacking** (see Box II).

**4. With regard to the title,**

- ☒ the text is approved as submitted by the applicant.
- ☐ the text has been established by this Authority to read as follows:

**5. With regard to the abstract,**

- ☒ the text is approved as submitted by the applicant.
- ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

**6. The figure of the drawings to be published with the abstract is Figure No.**

- ☒ as suggested by the applicant.
- ☐ because the applicant failed to suggest a figure.
- ☐ because this figure better characterizes the invention.

1 \_\_\_\_\_  
☐ None of the figures.

## INTERNATIONAL SEARCH REPORT

International Application No

/GB 00/00814

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC 7 D01D5/08 D01F6/06

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 D01D D01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 187 390 A (GORE ROBERT W) 5 February 1980 (1980-02-05) claims 1,17,18	1, 12, 14-31
X	<p>-----</p> <p>NKANSAH M A ET AL: "Modelling the effects of negative Poisson's ratios in continuous-fibre composites" JOURNAL OF MATERIALS SCIENCE, vol. 28, 1993, pages 2687-2692, XP002142194 page 2687, column 2, line 1 - line 16</p> <p>-----</p> <p>-/--</p>	1, 12, 14-31

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

10 July 2000

Date of mailing of the international search report

28/07/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
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 Fax: (+31-70) 340-3016

Authorized officer

Tarrida Torrell, J

## INTERNATIONAL SEARCH REPORT

International Application No

/GB 00/00814

## C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CADDOCK B D ET AL: "Microporous materials with negative Poisson's ratios: I. Microstructure and mechanical properties" JOURNAL OF PHYSICS. D: APPLIED PHYSICS, vol. 22, 1989, pages 1877-1882, XP000915206 page 1877, column 1, line 1 - line 19 ---	1, 12, 14-31
X	PICKLES A P ET AL: "THE EFFECT OF POWDER MORPHOLOGY ON THE PROCESSING OF AUXETIC POLYPROPYLENE (PP OF NEGATIVE POISSON'S RATIO)" POLYMER ENGINEERING & SCIENCE, US, SOCIETY OF PLASTICS ENGINEERS, vol. 36, no. 5, 15 March 1996 (1996-03-15), pages 636-642, XP000594968 ISSN: 0032-3888 the whole document ---	1, 6, 7, 12-31
A	BURKE M: "A STRETCH OF THE IMAGINATION" NEW SCIENTIST, GB, IPC MAGAZINES, LONDON, vol. 154, no. 2085, 7 June 1997 (1997-06-07), pages 36-39-39, XP002107878 ISSN: 0262-4079 the whole document ---	1-31
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## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

T/GB 00/00814



Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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			DE 2123316 A	02-12-1971
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EP 0253513	A	20-01-1988	JP 1980371 C	17-10-1995
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			JP 6099513 B	07-12-1994
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			DE 3781056 T	18-03-1993
			JP 1982609 C	25-10-1995
			JP 7005667 B	25-01-1995
			JP 63159408 A	02-07-1988
			US 4879076 A	07-11-1989

## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P/14399.WO		<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/PEA/416)	
International application No. PCT/GB00/00814	International filing date (day/month/year) 06/03/2000	Priority date (day/month/year) 06/03/1999	
International Patent Classification (IPC) or national classification and IPC D01D5/08			
Applicant BOLTON INSTITUTE OF HIGHER EDUCATION et al.			
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 5 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 1 sheets.</p>			
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> <li>I <input checked="" type="checkbox"/> Basis of the report</li> <li>II <input type="checkbox"/> Priority</li> <li>III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</li> <li>IV <input type="checkbox"/> Lack of unity of invention</li> <li>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</li> <li>VI <input type="checkbox"/> Certain documents cited</li> <li>VII <input checked="" type="checkbox"/> Certain defects in the international application</li> <li>VIII <input checked="" type="checkbox"/> Certain observations on the international application</li> </ul>			
Date of submission of the demand  04/10/2000		Date of completion of this report  30.03.2001	
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465		Authorized officer  Schram, H  Telephone No. +49 89 2399 2068 	

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00814

**I. Basis of the report**

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*

**Description, pages:**

1-18 as originally filed

**Claims, No.:**

3-31 as originally filed

1,2 as received on 10/03/2001 with letter of 08/03/2001

**Drawings, sheets:**

1/1 as originally filed

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

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EXAMINATION REPORT**

International application No. PCT/GB00/00814

- ☐ the description,      pages:  
☐ the claims,      Nos.:  
☐ the drawings,      sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Yes:	Claims 1-31
	No:	Claims
Inventive step (IS)	Yes:	Claims 1-31
	No:	Claims
Industrial applicability (IA)	Yes:	Claims 1-31
	No:	Claims

2. Citations and explanations  
**see separate sheet**

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:  
**see separate sheet**

**VIII. Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:  
**see separate sheet**

**INTERNATIONAL PRELIMINARY**

International application No. PCT/GB00/00814

**EXAMINATION REPORT - SEPARATE SHEET**

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Cont. of Section V

1. The present invention relates to synthetic auxetic materials. Such materials are known from e.g. the following documents:

- D1 The Effects of Powder Morphology on the Processing of Auxetic Polypropylene, Pickles A. P., Alderson, K. L. and Evans, K. E., Polymer Engineering & Science, vol. 36, no. 5, 1996, p. 636-642.
- D2 Microporous materials with negative Poisson's ratios: I. Microstructure and mechanical properties, Caddock B. D. et al, Journal of Physics D: Applied Physics, vol. 22, 1989, p. 1877-1882.
- D3 Modelling the effects of negative Poisson's ratios in continuous-fibre composites, Nkansah M. A. et al., Journal of Materials Science, vol. 28, 1993, p. 2687-2692.

The present invention is characterized by the novel feature that the auxetic material is of the form of filaments or fibres, cf. claims 1 and 2 (see p. 3, l. 13 - 14).

No hint or indication to the above mentioned feature was found in the teachings of the prior art documents. In particular, document D1 discloses that auxetic material can be obtained by compaction and sintering of polymer powder, which is then extruded into large cylindrical rods (cf. p. 10, l. 17 - 20 of the description of the application). Also documents D2 and D3 are silent about auxetic material which is of the form of filaments or fibres. Document US-A-4 187 390 (D4, X-doc.) discloses a PFTE micro-structure characterized by nodes interconnected by fibrils. Since this document appears to be silent about whether this porous material displays auxetic behaviour or not, the subject-matter of claim 1; appears to be novel with respect to document D4 as well.

Consequently, having regard to the available prior art, the subject-matter of claims 1 and 2 appears to be new and to involve an inventive step within the meaning of Articles 33(2) and 33(3) PCT.



**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/00814

2. The dependent claims 3 - 11 relate to particular embodiments of the method according to claim 2, and likewise appear to meet the requirements of Articles 33(2) and 33(3) PCT. Claims 14, 15, 19, 25 - 31 are independent use claims, whereas claims 16 - 18 and 20 - 24 are particular embodiments of the fibre-reinforced composite material and personal protective clothing according to claims 15 and 19, respectively, and likewise appear to meet the requirements of Articles 33(2) and 33(3) PCT.
3. Since it appears that the claimed invention can be made or used in a technological sense in industry, the claimed invention appears to be industrial applicable within the meaning of Articles 33(4) PCT.

**Cont. of Section VII**

1. One of the documents D1 - D3 and document D4 should have been identified in the description and the relevant background art disclosed therein should have been discussed. The requirements of Rule 5.1(a)(ii) PCT are, thus, not fulfilled.
2. The independent claims should have cast in the two-part form based on e.g. document D1, cf. Rule 6.3(b) PCT.

**Cont. of Section VIII**

1. Claim 12 is a "product-by-process" claim. Claims for products are admissible only if the products as such fulfil the requirements of Art. 33 PCT. A product is not rendered novel merely by the fact that it is produced by means of a new process. Since the "auxetic polymeric material of filamentary or fibrous form" according to claim 12 is not further defined, a lack of clarity arises, cf. Art. 6 PCT. Also note that the presence of two independent product claims (1 and 12) renders the claims as a whole unclear, cf. Art. 6 PCT. Claim 12 should hence have been deleted. Claim 13 could be maintained as a dependent claim, but should be renumbered as claim 2, cf. Rule 6.4(c) PCT.

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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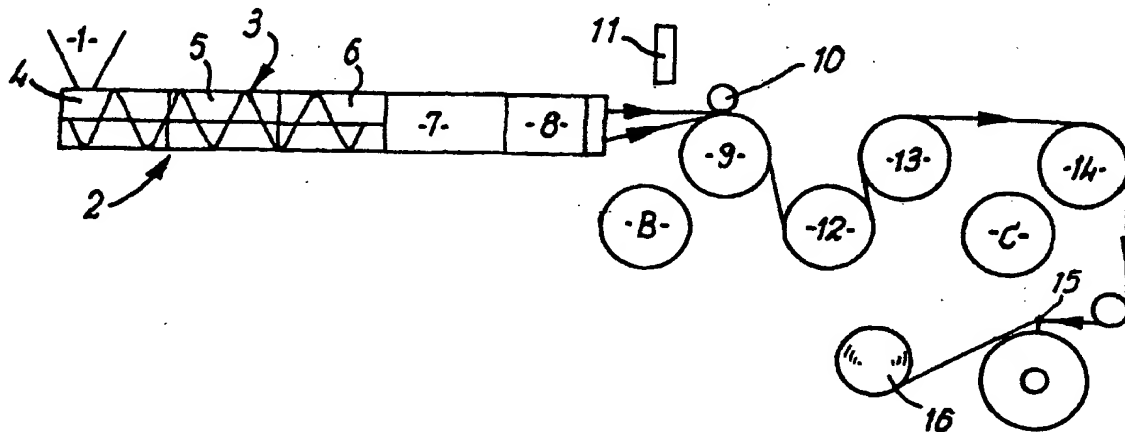
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amendments.*

(54) Title: AUXETIC MATERIALS



## (57) Abstract

An auxetic material, which has a negative Poisson ratio so that it has the property of expanding or contracting transversely to a direction in which it is extended or compressed, is made in filamentary or fibrous form. A suitable process involves cohering and extruding heated polymer powder so that the cohesion and extrusion is effected with spinning to produce auxetic filaments. Typically the powder is heated to a temperature sufficient to allow some degree of surface melting yet not high enough to enable bulk melting.

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# INTERNATIONAL SEARCH REPORT

Inter Application No

PCT/GB 00/00814

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 D01D5/08 D01F6/06

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 187 390 A (GORE ROBERT W) 5 February 1980 (1980-02-05) claims 1,17,18	1,12, 14-31
X	NKANSAH M A ET AL: "Modelling the effects of negative Poisson's ratios in continuous-fibre composites" JOURNAL OF MATERIALS SCIENCE, vol. 28, 1993, pages 2687-2692, XP002142194 page 2687, column 2, line 1 - line 16 -/--	1,12, 14-31

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

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## INTERNATIONAL SEARCH REPORT

Inte. Application No

PCT/GB 00/00814

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CADDOCK B D ET AL: "Microporous materials with negative Poisson's ratios: I. Microstructure and mechanical properties" JOURNAL OF PHYSICS. D: APPLIED PHYSICS, vol. 22, 1989, pages 1877-1882, XP000915206 page 1877, column 1, line 1 - line 19 ---	1,12, 14-31
X	PICKLES A P ET AL: "THE EFFECT OF POWDER MORPHOLOGY ON THE PROCESSING OF AUXETIC POLYPROPYLENE (PP OF NEGATIVE POISSON'S RATIO)" POLYMER ENGINEERING & SCIENCE, US, SOCIETY OF PLASTICS ENGINEERS, vol. 36, no. 5, 15 March 1996 (1996-03-15), pages 636-642, XP000594968 ISSN: 0032-3888 the whole document ---	1,6,7, 12-31
A	BURKE M: "A STRETCH OF THE IMAGINATION" NEW SCIENTIST, GB, IPC MAGAZINES, LONDON, vol. 154, no. 2085, 7 June 1997 (1997-06-07), pages 36-39-39, XP002107878 ISSN: 0262-4079 the whole document ---	1-31
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informa patent family members

Inter Application No

PCT/GB 00/00814

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